

Operational Products of the Space Weather Application Center Ionosphere (SWACI) and capabilities of their use

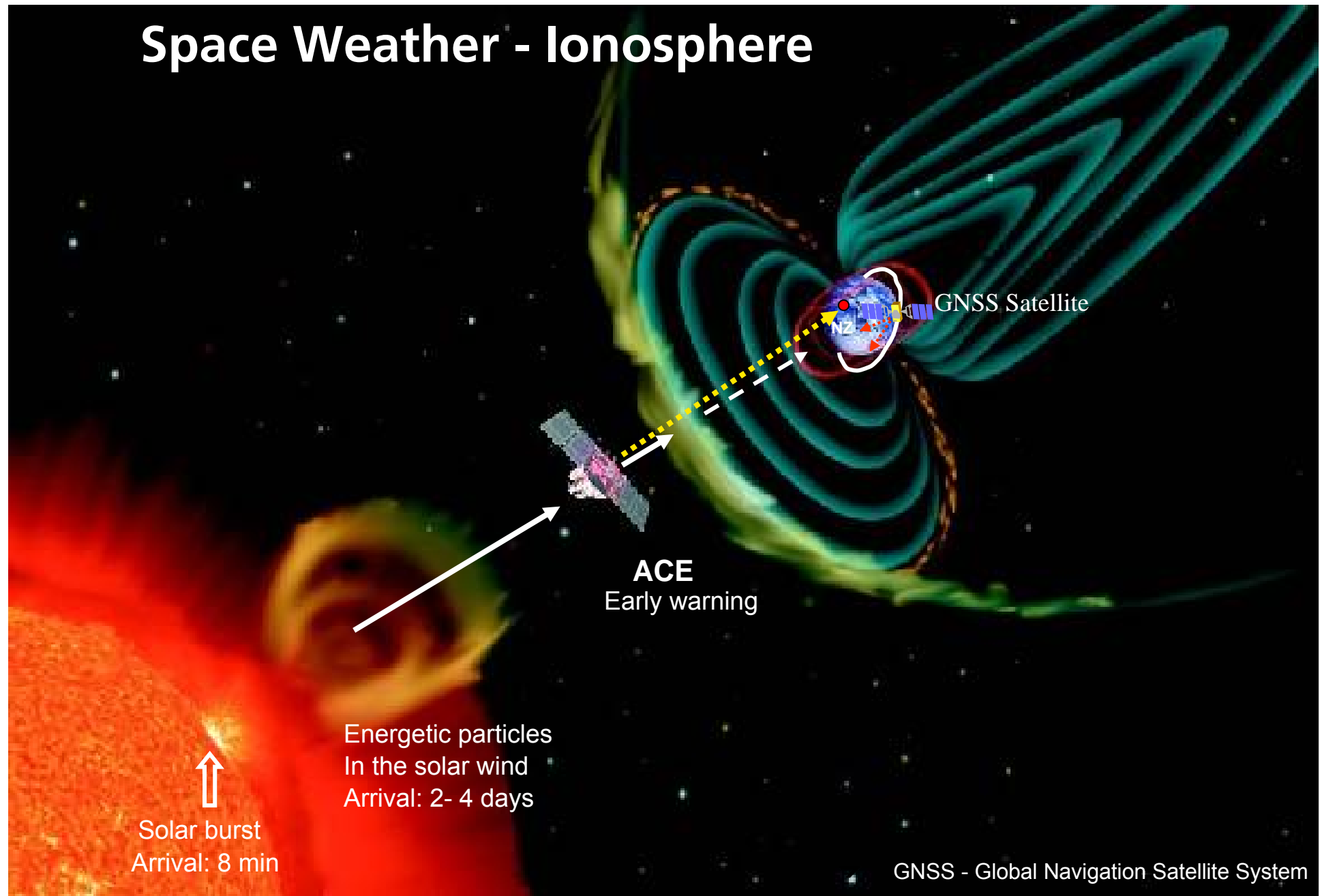
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OUTLINE

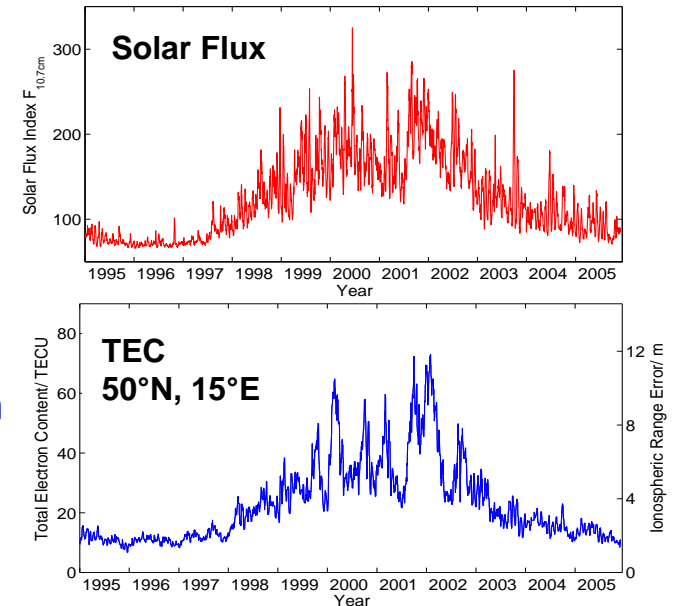
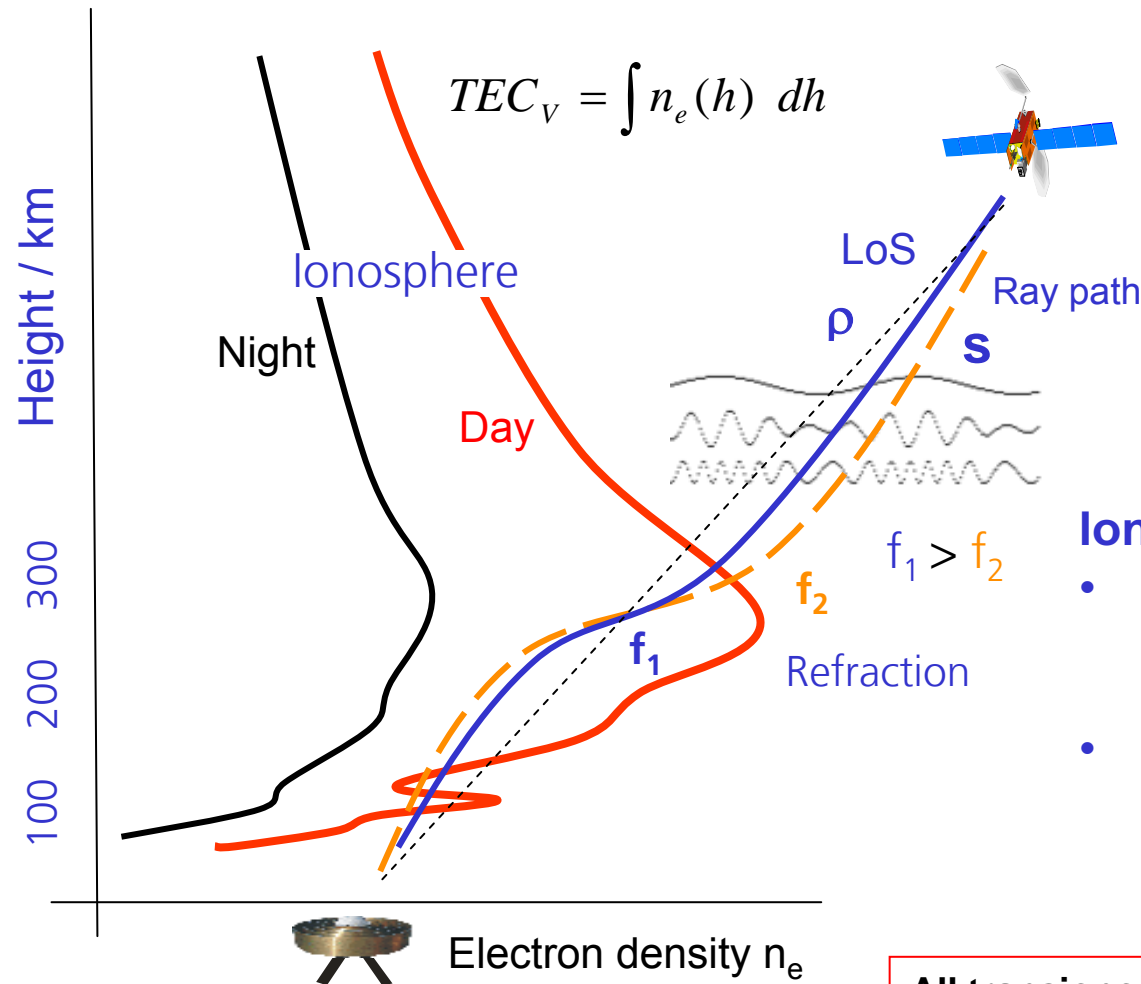
- Introduction
- Space Weather Application Center-Ionosphere
- Ionosphere monitoring and derived products
 - Space based techniques
 - Ground based techniques
- Selected service products & their use
- Summary

Space Weather - Ionosphere



Transionospheric Radio Wave Propagation

Electron density n_e & Total Electron Content (TEC) are closely related to the solar irradiance



Ionosphere causes

- **Regular effects**
 - signal delay, range errors
 - rotation of polarisation plane
- **Irregular effects**
 - Radio scintillations,
 - Defocussing of radar images
 - Hazardous misleading information

All transionospheric radio systems operating at frequencies < 10 GHz are affected

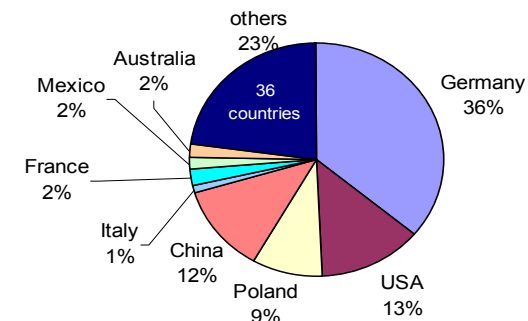
Space weather Application Center Ionosphere (SWACI)

<http://swaciweb.dlr.de>

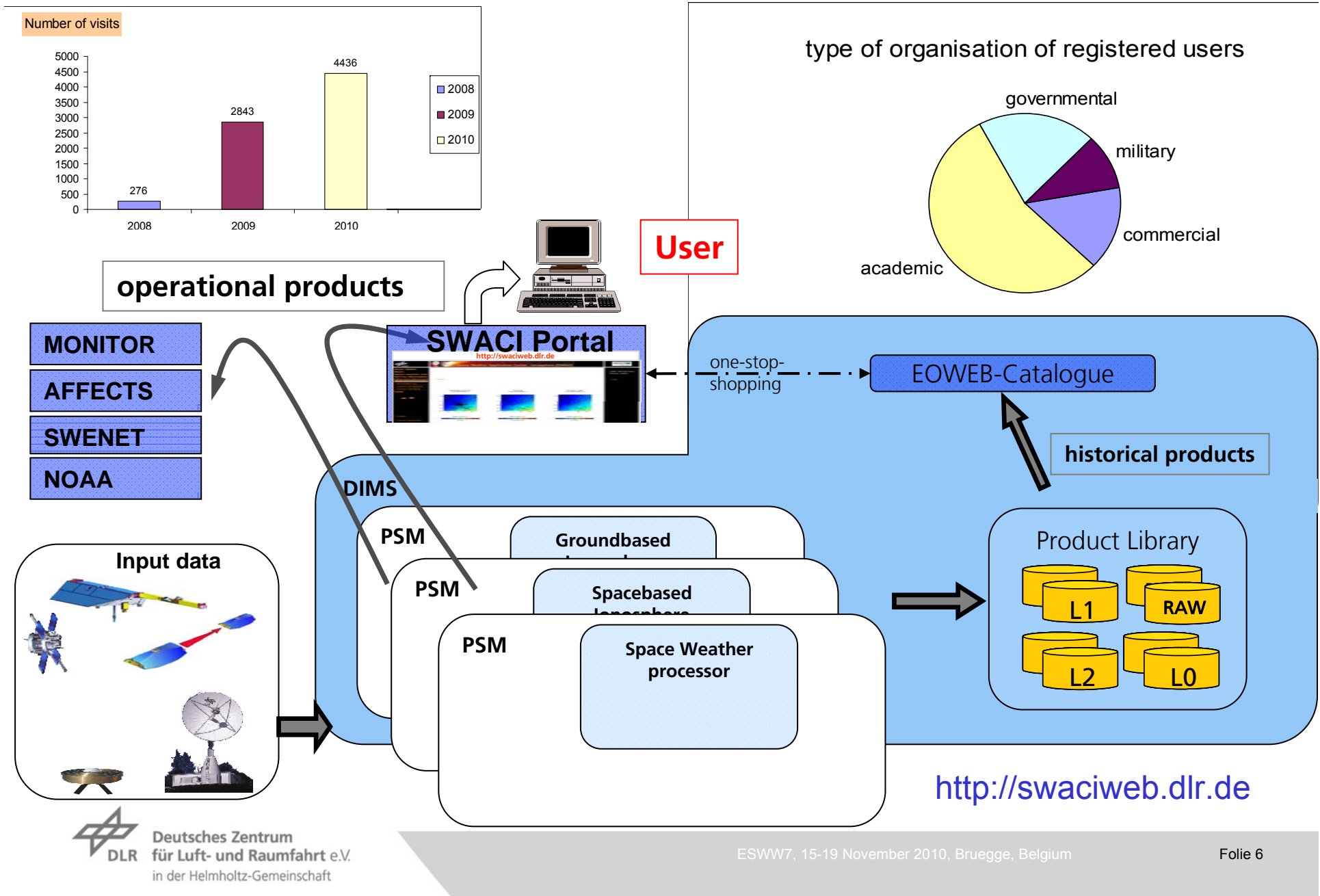
- The **Space Weather Application Center - Ionosphere** (SWACI) is a joint project of the Institute of Communications and Navigation and the German Remote Data Center of DLR.
- The project is essentially supported by the German State Government of Mecklenburg-Vorpommern, will be finished in March 2011.
- SWACI data base is mostly related to ground and space based GNSS measurements.
- Data in particular suited to characterize ionospheric conditions along transionospheric radio links.
- SWACI information shall support operators and users of transionospheric radio systems in communication, navigation and remote sensing.



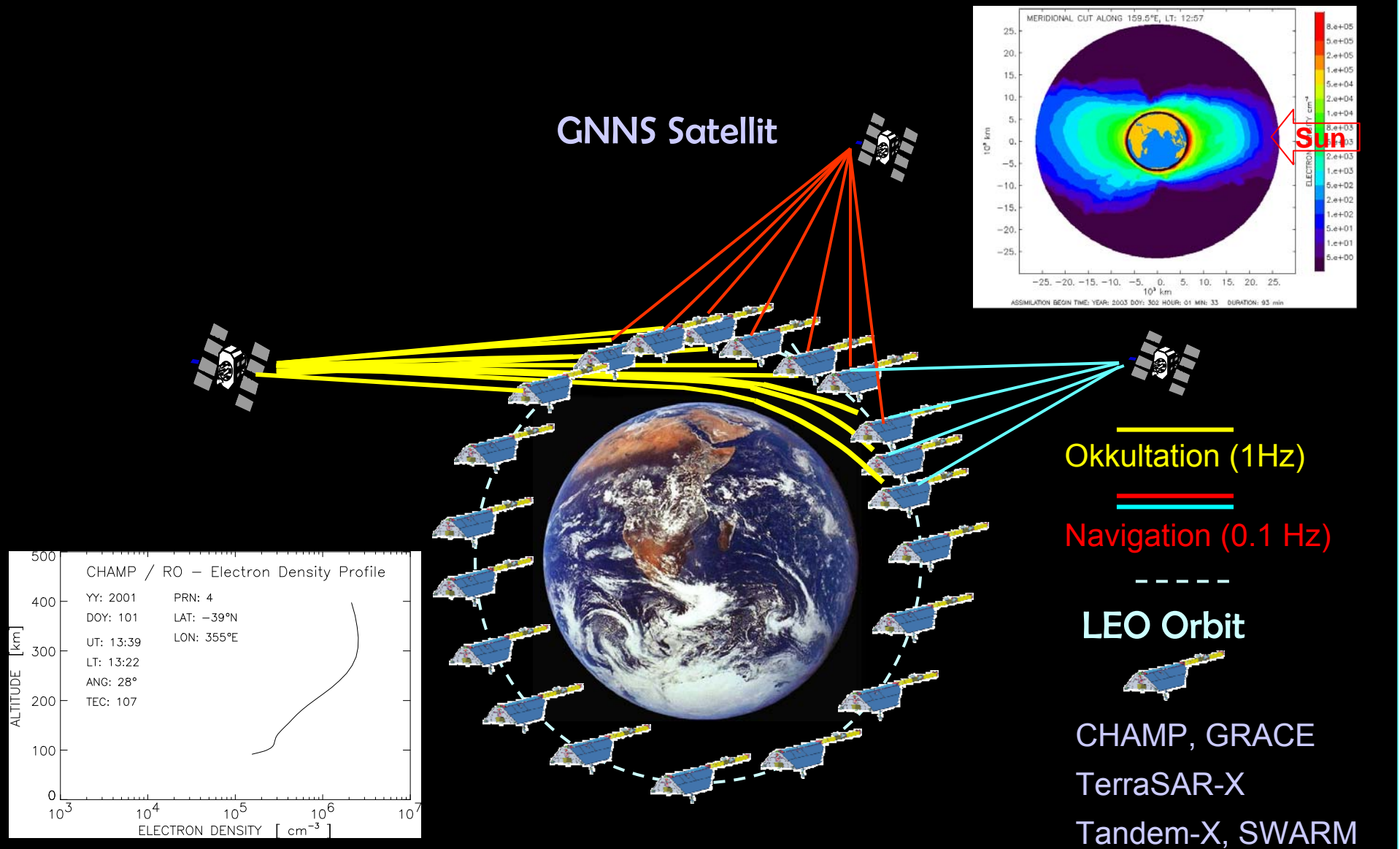
Worldwide access, e.g in October 2010



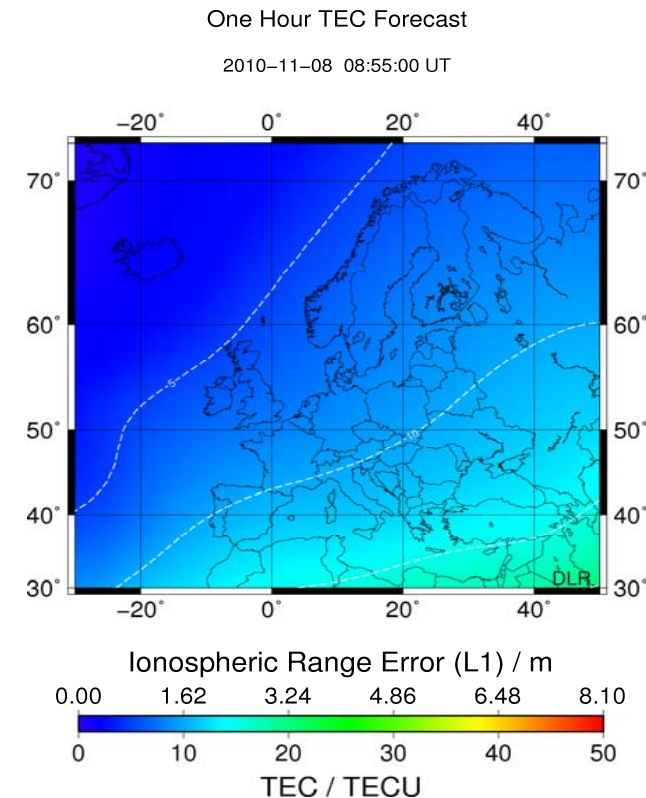
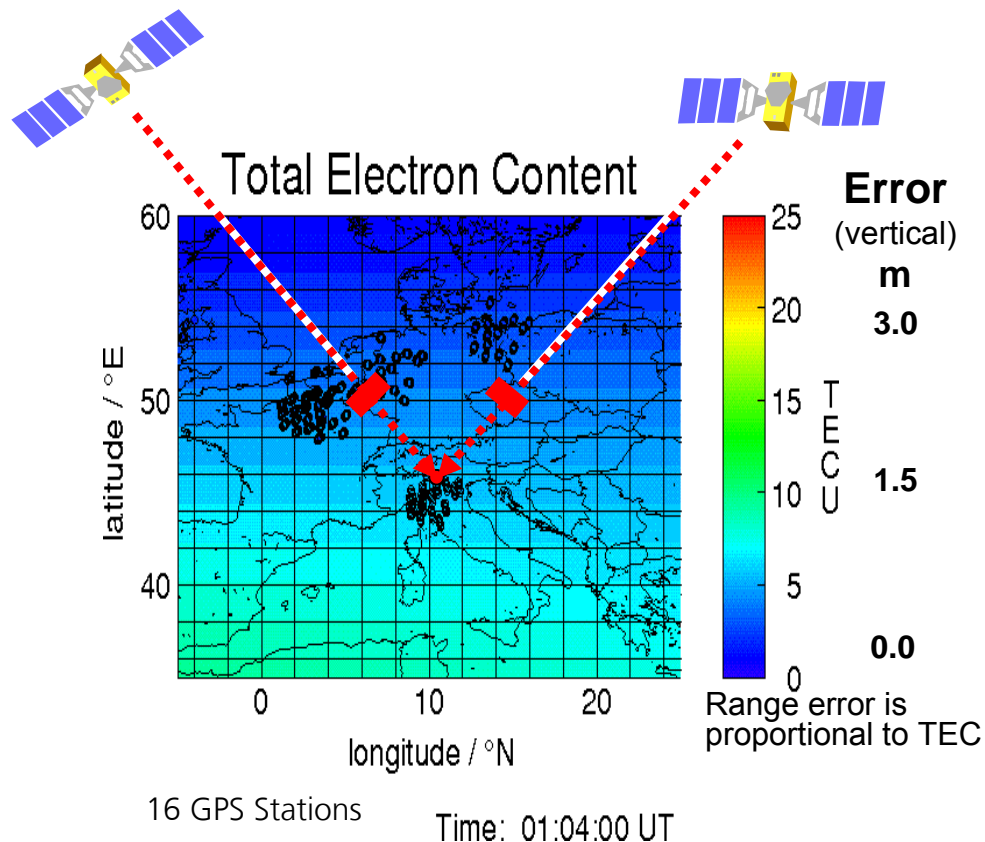
SWACI service architecture



Space Based Monitoring of the Ionosphere



Ionosphere weather service: Now- & Forecast



- Near real time ground based GNSS* measurements enable the computation of high resolution TEC maps over certain areas (e.g. Europe, Japan, USA)
- Maps enable the correction of single frequency GNSS measurements
- Ionosphere is the biggest error source in single frequency applications.
- Model assisted reconstruction enables TEC forecast 1 hour ahead

Use of SWACI TEC maps for the Single-Frequency Precise Point Positioning Experiment of the TU Delft in Mai 2005

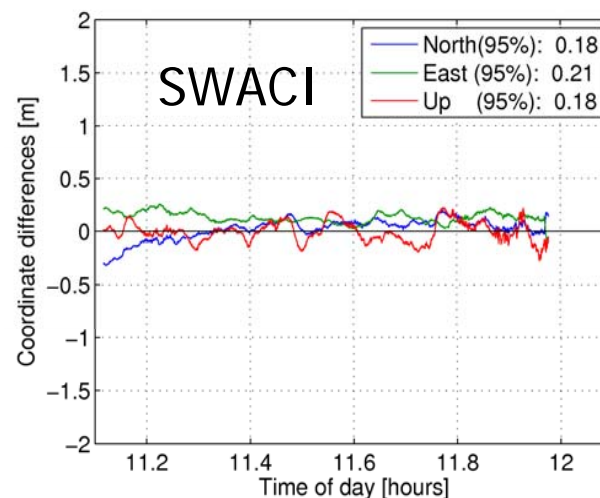
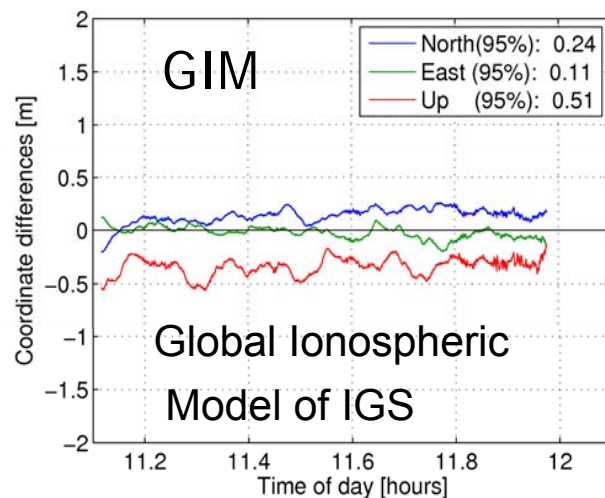


Requirements:

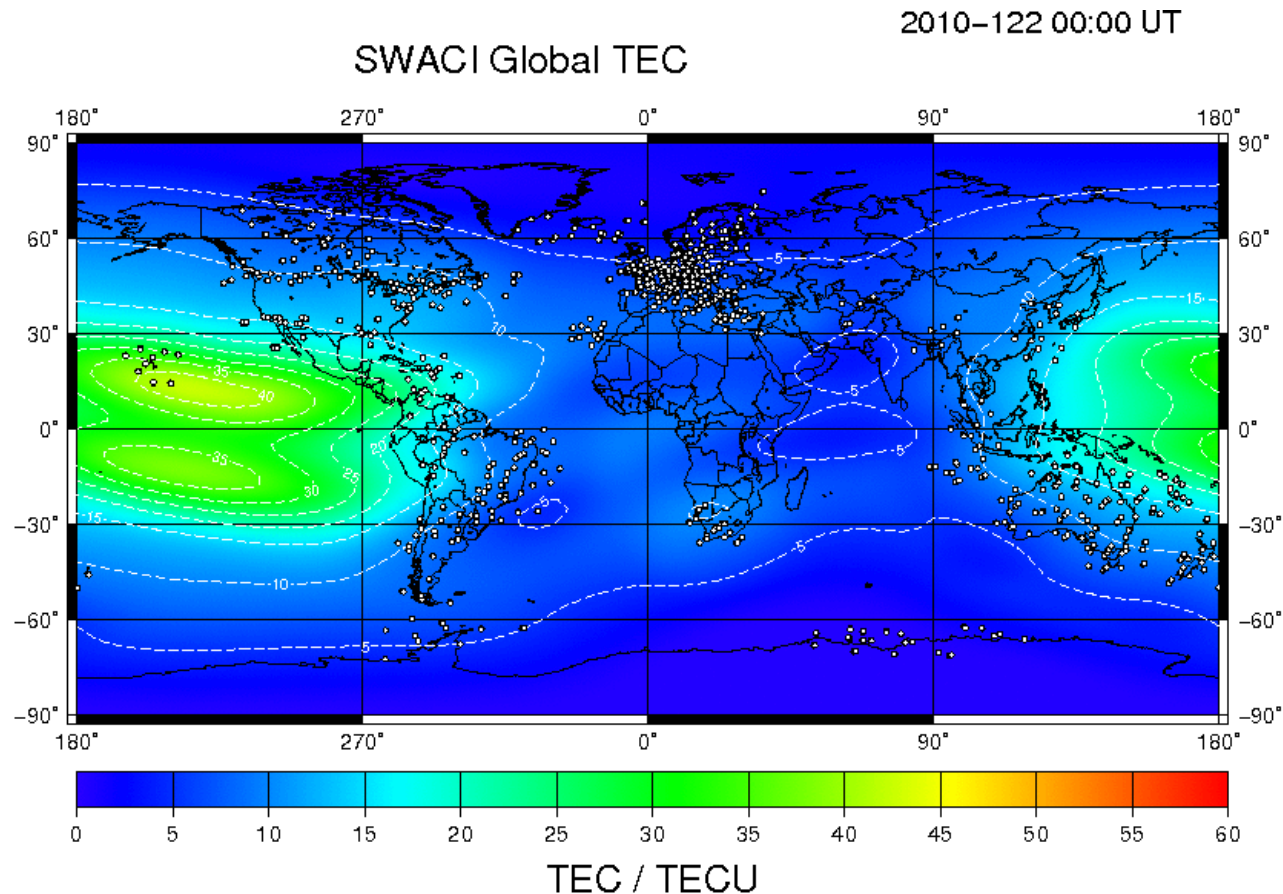
- Good accuracy of TEC
- Sufficient spatial and temporal resolution

Results of the Experiment:

- SWACI correction enables vertical positioning accuracy in dm range,
- SWACI can be improved by covering a larger region.

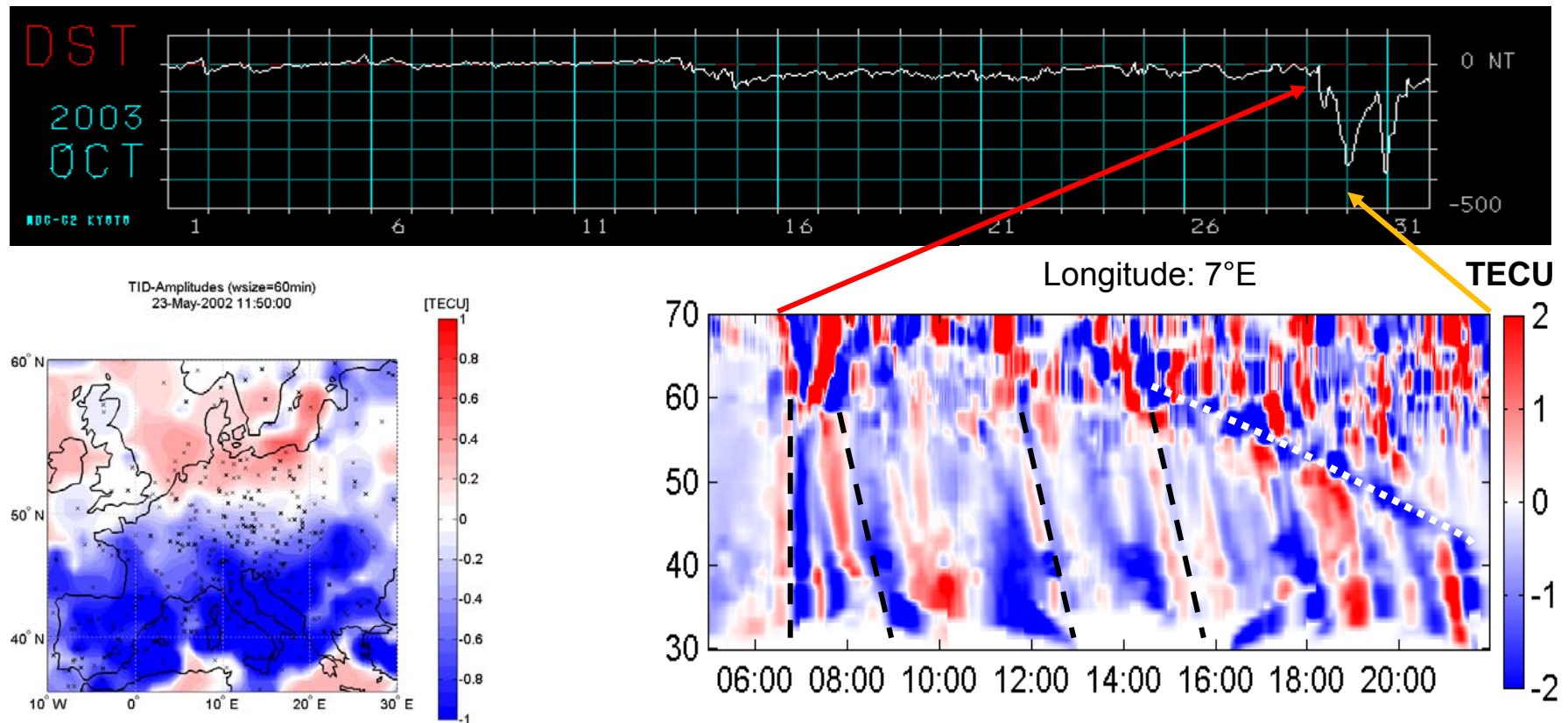


Global TEC monitoring



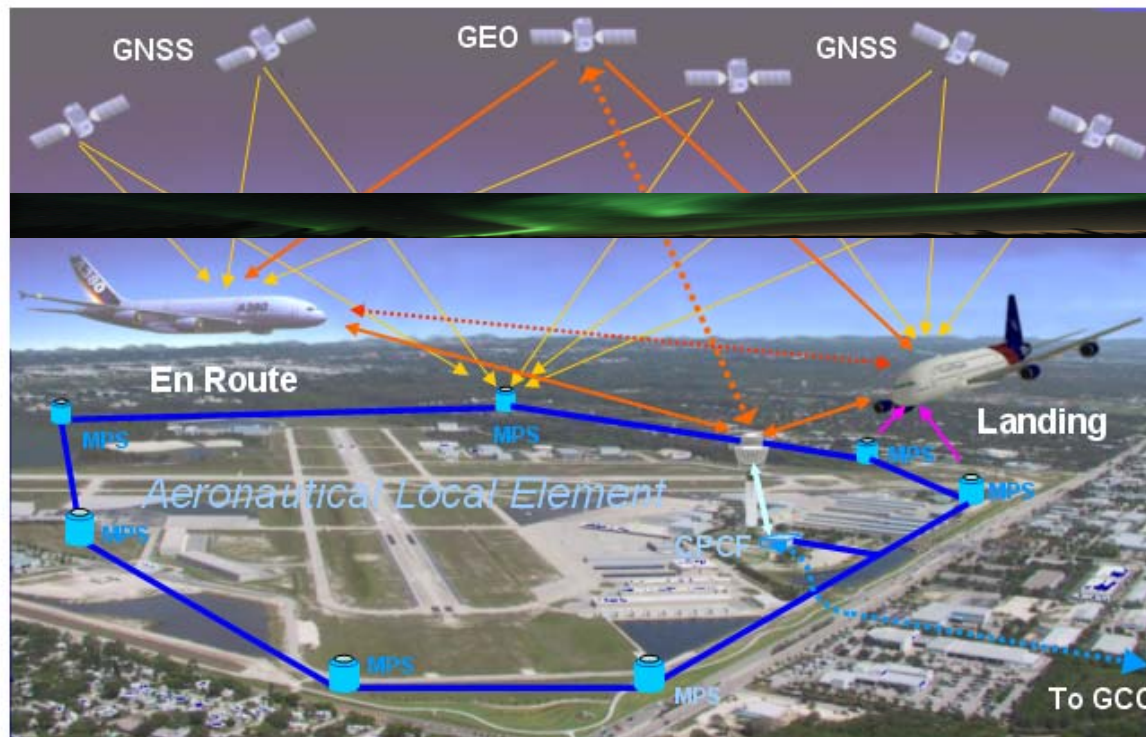
- Since July 2010 global TEC maps are routinely produced in DLR. Maps are available via SWACI every 5 min and therefore fulfil requirements of single frequency users.
- Data base is provided by the **Real Time Pilot Project** of the International GNSS Service (IGS).
- Global TEC model has been developed to act as background model for data assimilation

Propagation of TIDs during ionospheric storms



- Immediate propagation of the perturbation at the onset (electric field)
- Wavelike propagation of disturbances during the main phase of the storm on 29 October 2003 (speeds up to ≈ 1000 m/s)
- High latitude disturbance zone (northward of the trough) moves also equatorward (speed ≈ 70 m/s)

Safety of Life (SoL) application - aviation



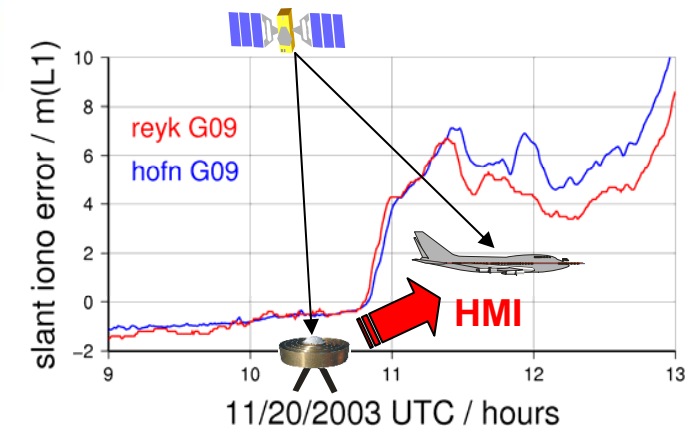
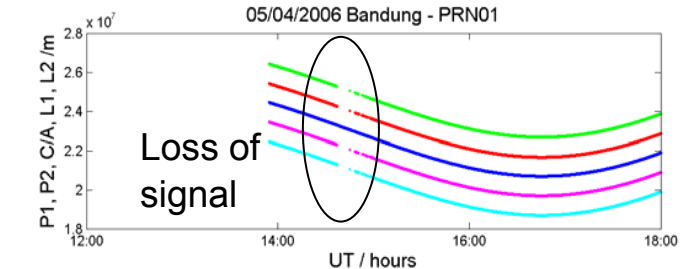
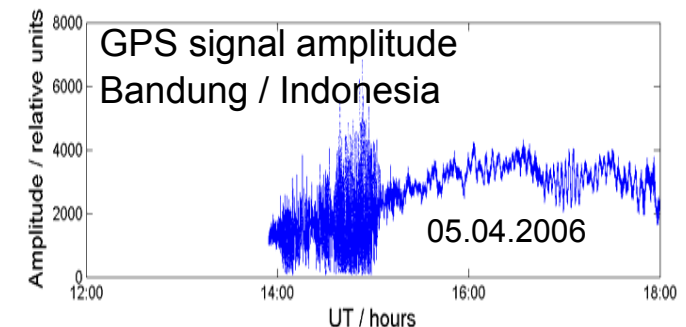
- Degradation of **accuracy, integrity, availability and continuity** of signals due to space weather effects in the ionosphere



Operational **detection and tracing** of ionospheric **perturbations** needed
Ionospheric **"Threat-Model"** required

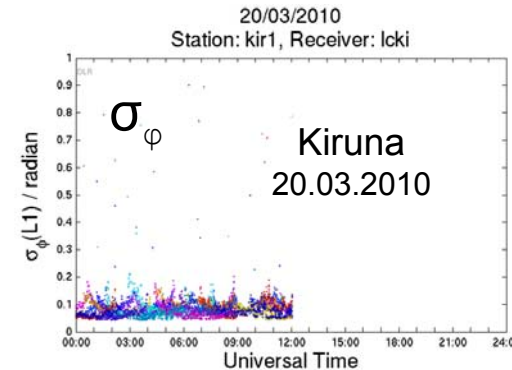
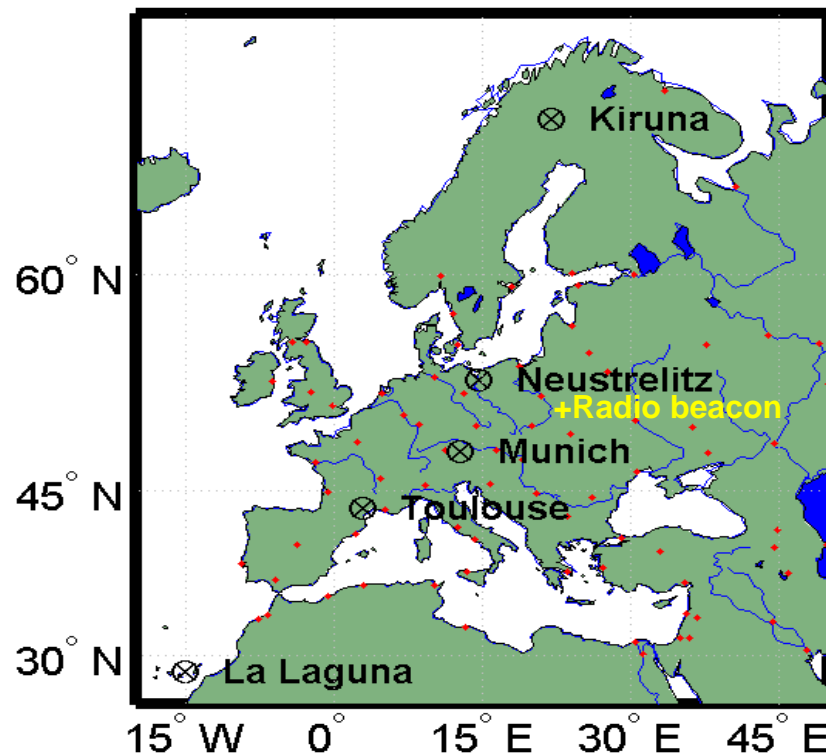


Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft



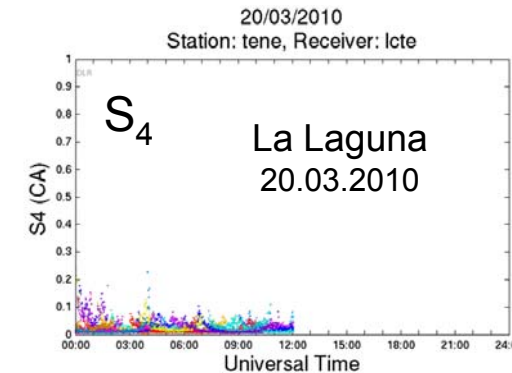
HMI: Hazardous Misleading Information

GPS scintillation monitoring network of DLR



Update: 1 min

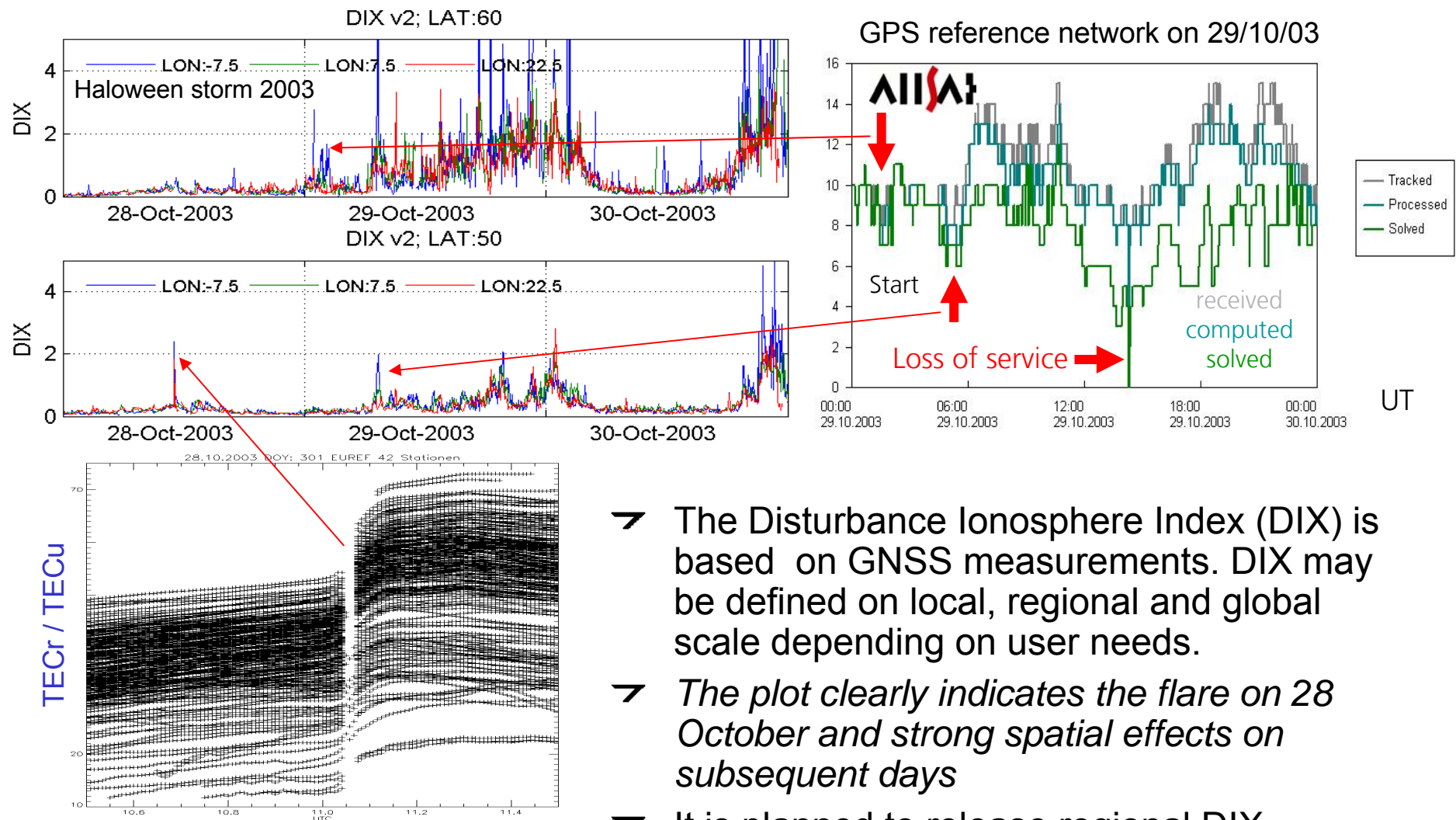
Remote access to
all stations of the
network (EVNet)



Data reduction on
observation site by
computing
scintillation
parameters

- DLR operates a network of high rate dual frequency GPS receivers (20-50 Hz) for scintillation monitoring.
- Network provides actual scintillation data for further distribution via SWACI.
- Extension of the network is planned towards North and South (Ethiopia), the network includes capabilities to receive Galileo signals.
- Network contributes to ESA project MONITOR.

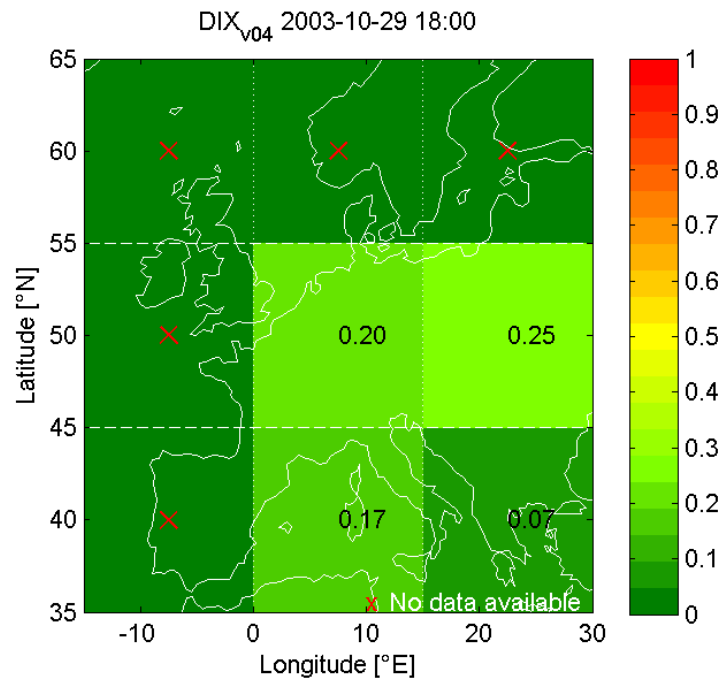
Under development: Disturbance Ionosphere Index (DIX)



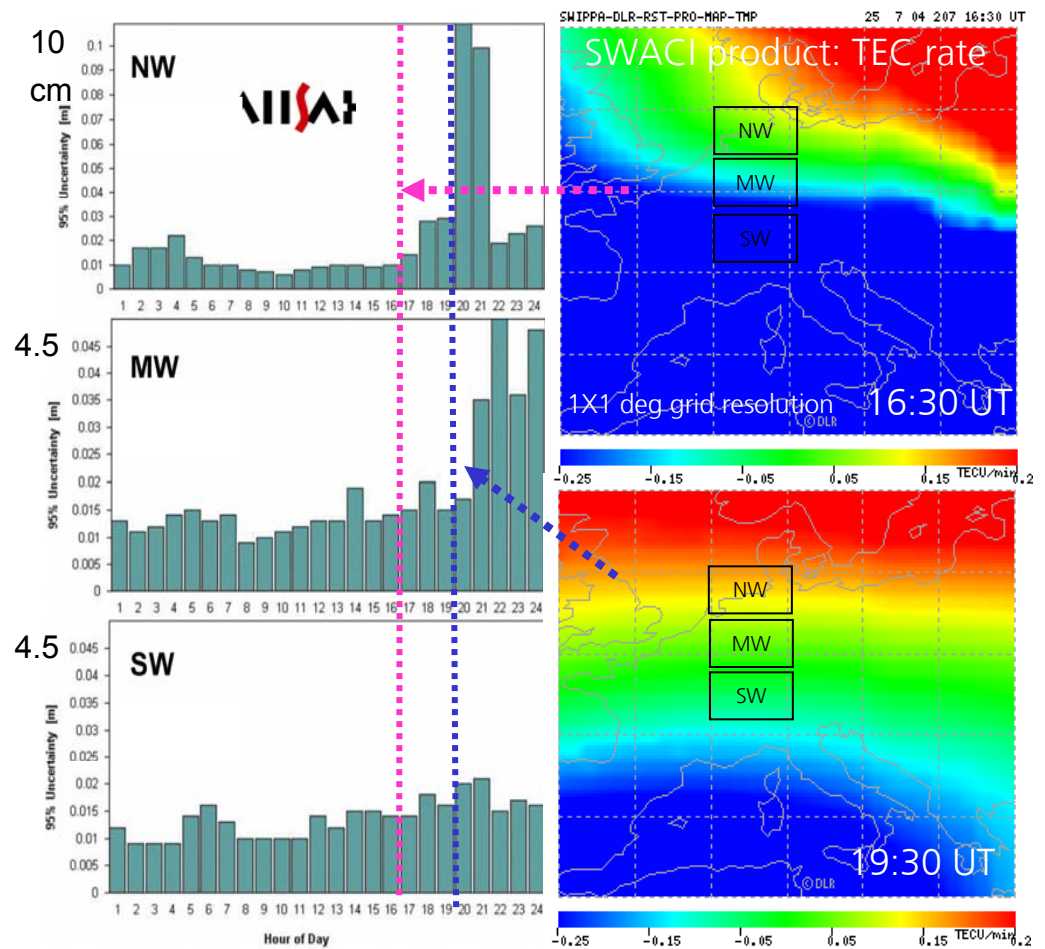
Universal Time / hours.

- The Disturbance Ionosphere Index (DIX) is based on GNSS measurements. DIX may be defined on local, regional and global scale depending on user needs.
- *The plot clearly indicates the flare on 28 October and strong spatial effects on subsequent days*
- It is planned to release regional DIX products via SWACI in January 2011

Use of DIX in precise positioning



- Perturbation degree is quantified by the regionalized Disturbance Ionosphere Index DIX
- The index can directly be used by customers to estimate the GNSS Performance
- Forecast of DIX is future task



Performance of the GPS reference network of Allsat GmbH, Hannover degrades during the ionospheric storm on 25 July 2004

Summary

- **Transionospheric radio systems in communication, navigation, positioning and remote sensing are principally impacted by the ionospheric plasma at operating frequencies < 10 GHz.**
- **SWACI operational service provides products such as:**
 - Regional and global TEC maps for ionospheric range error corrections in GNSS and remote sensing applications
 - Scintillation data along a meridional chain from high to low latitudes for detection of small scale irregularities
 - Disturbance Ionosphere Index (DIX) for detection of mid- to large scale perturbations (will be released in 2011)
 - Vertical electron density profiles from RO measurements
 - Topside reconstructions of the 3D electron density

Thank you for your attention !

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